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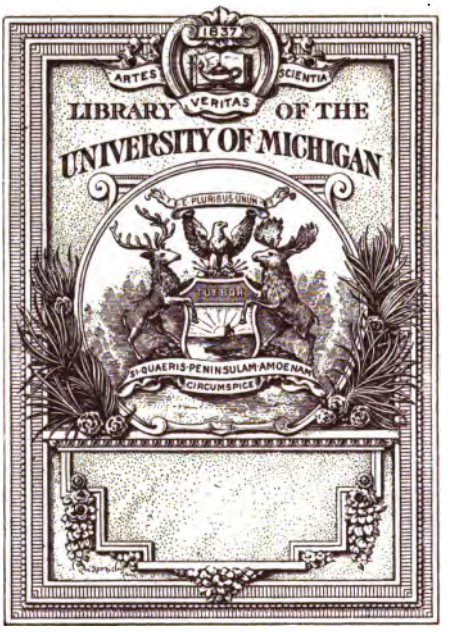

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WHITE ELM AND HACKBERRY FOREST AT STOCKTON, BROOKS COUNTY, KANS.

Hackberry trees in the foreground.

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U. S. DEPARTMENT OF AGRICULTURE,

FOREST SERVICE—BULLETIN No. 66.

GIFFORD PINCHOT, Forester.

FOREST BELTS OF WESTERN KANSAS AND NEBRASKA.

BY

ROYAL S. KELLOGG,

FOREST ASSISTANT, FOREST SERVICE.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1905.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE,
Washington, D. C., September 7, 1905.

SIR: I have the honor to transmit herewith a manuscript entitled "Forest Belts of Western Kansas and Nebraska," by Royal S. Kellogg, Forest Assistant in the Forest Service, and to recommend its publication as Bulletin No. 66 of the Forest Service.

The map and six plates accompanying this report are necessary for its proper illustration.

Very respectfully,

GIFFORD PINCHOT,
Forester.

Hon. JAMES WILSON,
Secretary of Agriculture.

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ERRATA.

In the list of illustrations, page 6, for "Plate V" read "Plate VI," and for "Plate VI" read "Plate V."

In the legend to Plate I (frontispiece), in the list of illustrations and on the illustration, for "Brooks" read "Rooks."

In the legend to Plate VI, figure 2, in the list of illustrations and on the illustration, for "Buffalo County, Kans.," read "Buffalo County, Nebr."

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FOREST BELTS OF WESTERN KANSAS AND NEBRASKA.

TERRITORY INCLUDED.

The territory covered by this study embraces Kansas and Nebraska west of the ninety-ninth meridian and Colorado east of the one hundred and fourth meridian. The eastern boundary runs close to Kearney, Nebr., and Larned, Kans., the western about 50 miles east of Pueblo, Colo. The northern limit is the forty-third parallel, which forms the boundary between Nebraska and South Dakota, and the southern is the thirty-seventh parallel, the southern boundary of Kansas and Colorado. The area included within these limits is approximately 47,000 square miles in Nebraska, 34,000 square miles in Kansas, and 28,000 square miles in Colorado, or a total of 109,000 square miles.

PHYSICAL CONDITIONS.

TOPOGRAPHY.

In its broad outline western Kansas is a gently sloping plain, with little diversity of surface except that produced by the numerous water courses, whose beds vary from a few feet to 200 feet below the general upland level. The elevation ranges from about 1,500 feet above sea level near the eastern limit to 4,000 feet on the western boundary. There is some increase in altitude from south to north, but much less than from east to west.

Western Nebraska is much more rugged than western Kansas. Elevations run from 1,845 feet at Bloomington, on the Republican River, to 5,300 feet near the Wyoming line, south of the North Platte River. In Cheyenne, Banner, and Scotts Bluff counties and in Sioux, Dawes, and Shannon counties, along the extensive line of hilly bluffs which stretch from eastern Wyoming across northwestern Nebraska and into South Dakota, and which are known as Pine Ridge, the country becomes semimountainous, and is characterized by precipitous bluffs, towering buttes, and oftentimes deeply cut, impassable canyons. One of the most striking buttes is Scotts Bluff, which rises 780 feet above the level of the North Platte River. In southwestern Nebraska only are there comparatively level high plains like those of eastern Colorado and western Kansas.

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The great sand-hill region, which stretches from the North Platte northward to the Niobrara, and covers approximately one-third of the State, with its endless succession of hills and ridges, basins and valleys, is as monotonous in a way as the level plains of western Kansas. Both are seemingly boundless, and the eye may range over them for miles without hindrance. (See Pl. II, fig. 1.)

STREAMS.

The principal rivers of western Nebraska and western Kansas are the Niobrara, North Loup, Middle Loup, South Loup, Dismal, North Platte, South Platte, Republican, North Solomon, South Solomon, Saline, Smoky Hill, Arkansas, and Cimarron. There are numerous tributary creeks and streams. (See map.) None of the rivers normally carries a large volume of water, and some of them, as well as many of the creeks, go dry during periods of deficient rainfall. Yet, even when no water is visible in the beds of such streams as the Platte and the Arkansas, one has but to dig down in the sand a foot or two to find water in abundance. There is a constant underflow, and trees growing in the valleys of these streams do not suffer because the surface flow occasionally ceases.

ROCK.

Outcropping rock is wholly absent over large areas in western Kansas and western Nebraska. Most of the rock found is of two general classes, sandstone and limestone, both of which easily disintegrate and form soil. Pine Ridge in Nebraska is especially characterized by the soft, light-colored Arikaree sandstone. Shale is abundant in many places, and, when broken down, produces clay and gumbo soils. In western Kansas and southwestern Nebraska there are extensive bodies of irregular, coarse-grained, mortarlike rock of Tertiary formation, locally known as "mortar beds" or "magnesia." The unconsolidated Tertiary deposits often consist of beds of material ranging from sand to coarse gravel, brought down from the Rocky Mountains, and showing forms characteristic of such long transportation.

SOIL.

All the main streams have sandy beds, and for the most part sandy loam or loam soils in their valleys. The smaller streams are commonly less sandy, and many of them have fairly heavy soils. Correlated with this difference in soil is a marked difference in the species of trees and their manner of growth. The cottonwood and willow are the only native broadleaf trees which really prefer a sandy soil, so they often form the sole tree growth along the larger streams. This

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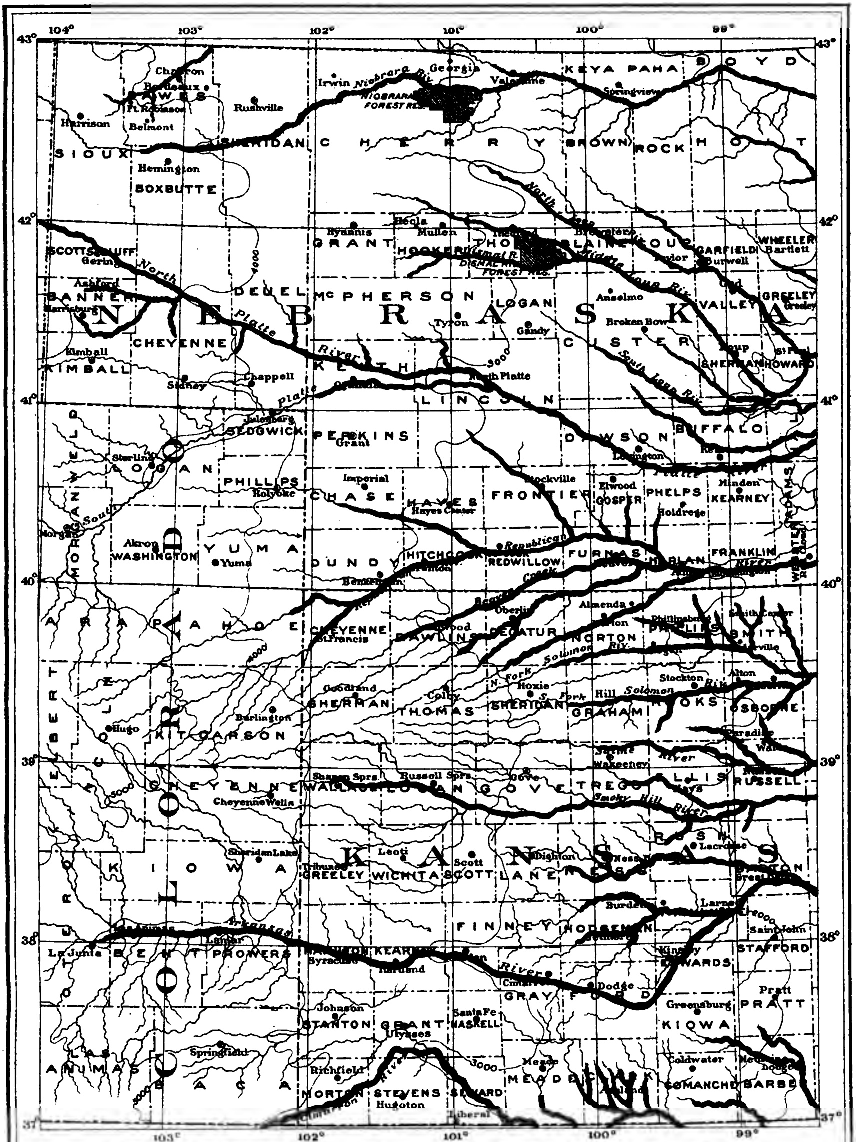

FORESTS IN WESTERN KANSAS AND NEBRASKA

Pine Ridge Type ▬▬ Valley Type

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is notably the case along the Arkansas, Smoky Hill, and Platte rivers. Cottonwood stands are generally open. Each tree has but little modifying contact with its neighbors. On the minor streams, which have the heavier soil, other species predominate and cottonwood and willow are less abundant. Growth is more dense in such situations, and an approach is made occasionally to true forest conditions.

The greater proportion of the uplands in western Kansas and Nebraska is covered by deposits of very fine sand (0.1 to 0.05 mm.) and silt (0.05 to 0.005 mm.), known geologically as "plains marl" and "loess." The plains marl occurs principally in western Kansas and eastern Colorado, and is often very deep. The loess is found in eastern Nebraska, extending westward to Colorado, along the southern line of the State, and to some extent in Kansas in the northern tier of counties. The depth is variable, but is estimated to average 100 feet, while in places, notably south of the Platte River, in Dawson and Lincoln counties, loess bluffs 200 feet or more in height are common. The soil formed from these deposits consists chiefly of very fine sand and silt, the latter usually forming more than 50 per cent of the soil material. The clay content is small, usually not exceeding 15 per cent. The soils derived from the plains marl and loess are very much alike. The former, however, usually contains a larger percentage of very fine sand. Calcareous matter is usually present, most often in the form of nodules.[a] It is an easily worked soil, very fertile—the valuable agricultural lands of eastern Nebraska being an example—and has a great capacity for moisture. The fact that cottonwoods and willows are found growing naturally on loess bluffs far above the water level is a good indication of its moisture-holding power.

In both States are numerous areas of loose sand, blown and worn into low hills. The main sand-hill region lies in Nebraska, north of the Platte River, and covers an area of about 25,000 square miles. The largest of the minor sand-hill areas forms a narrow belt, practically continuous, along the entire south side of the Arkansas River Valley, in western Kansas. A sand-hill area of considerable size is on the south side of the Cimarron River, in southwestern Kansas. Similar sand-hill areas occur south of the Platte River at various points.

The sand hills are generally covered with grass and shrubby vegetation, and retain moisture well. They take up water as readily as a sponge, and there is little surface run-off, no matter how heavy the downpour. The three Loup rivers, which rise in the sand hills of Nebraska, are among the finest streams in the West, and are

[a] Mechanical analyses of the plains marl and the loess are given in Bulletin 5 of the Bureau of Soils, pp. 12–14, and in Field Operations of the Bureau of Soils, 1903, pp. 934–953.

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remarkable for their steady flow of pure, cold water. The sand-bar willow is a native shrub of the sand hills in both Kansas and Nebraska, and evidences the good moisture condition of the soil.

A striking example of correlation between soil and forest growth is shown by the closeness with which the rock pine follows the sandstone and sand of the Arikaree formation in Nebraska.

CLIMATE.

The climate of nearly all this region is essentially semiarid. It is characterized by light and unevenly distributed precipitation, high winds, excessive evaporation, and great fluctuations of temperature. All these conditions become more marked from east to west, and are clearly reflected in the character of the forest growth and the gradual disappearance of tree species. This is fully shown in the discussion of the valley type and in the notes on the ranges of the various native species. (See p. 23.)

The average annual precipitation at Hays, Kans., is 20.9 inches, while that at Wallace, which is due west of Hays, near the Colorado line, is but 16.1 inches. In Nebraska the average precipitation at Kearney is 25.8 inches annually, at North Platte 17.7 inches, and at Gering 14.8 inches. These three places are all on the Platte River, and strikingly illustrate the increasing aridity toward the west. Fort Robinson, Nebr., in the Pine Ridge region, has an annual precipitation of 16.6 inches.

Of even more moment to forest growth than the low average rainfall are the fluctuations from year to year and the irregular distribution of rains throughout the year. The Weather Bureau records have been kept at Dodge, Kans., for thirty years, and during that period the precipitation of the driest year was only 10.1 inches, while the wettest year had 33.7 inches. The average precipitation at Dodge is nearly 20 inches, which, if well distributed, is sufficient for the growth of many tree species. The species actually found at that place, however, are necessarily those which are hardy enough to endure a year in which the precipitation is only 10 inches. This same fluctuation in precipitation prevails throughout the plains region.

One fact of great importance in connection with the rainfall is that the greater part of it comes at the time it is needed by vegetation of every kind. Three-fourths of the annual amount commonly falls between April 1 and October 1.

High wind velocities increase the evaporation, and experiments show that a wind which has a velocity of 10 miles per hour causes 3.8 times the evaporation from a water surface that there is in a calm. Since the average velocity on the plains is about 12 miles per hour, it may be safely said that the wind causes at least four times the evap-

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oration there would be in a calm.[a] In the spring, however, the velocity is considerably greater, and an average speed of 15 or 16 miles per hour may be maintained for a month at a time. The prevailing direction is northwesterly in winter and south to southwest in summer.

As a direct result of the dry atmosphere and the high winds there is a great evaporation from every surface capable of giving off moisture, whether it be water, soil, or leaf. Since this evaporation increases from east to west, while the rainfall decreases, there is a further lessening of the amount of moisture available for plant life from this cause.

The result of all these adverse climatic factors is that the common hardwood trees are confined closely to the water courses or to comparatively wet situations. Even the permanent subterranean water is not sufficient for all species; the excessive evaporation also limits plant distribution. It is entirely possible for water to be taken from a large leaf surface faster than it can be supplied by the roots, even when the latter are in soil which contains much moisture. The western farmer knows only too well that the "hot wind" may wither and kill his corn at times when the soil is comparatively moist. The blanched blades and tassels show plainly that the plants have proved unequal to the strain and have died because they could not take up water from below as fast as it was given off to the dry air.

Trees have been killed in seasons of severe drought, and there is no doubt that climatic conditions are the limiting factors in the distribution of the species belonging to the valley type. It is evident that anything which checks the wind and diminishes the evaporation will render conditions more favorable for tree growth. The sides of canyons which face the north, and are consequently less exposed to the summer winds and the intensity of the sun's rays, are often covered with shrubs and small trees, when the opposite side of the same canyon, with identical conditions in every other respect, contains almost no woody growth of any kind. Throughout this whole section north and northeast slopes are more favorable to every kind of tree growth than any others and than the open levels.

THE NATURAL FOREST.

Types.

The natural forest growth of Kansas and Nebraska is limited to the river courses and to a few upland areas of pine and cedar. The greater part of the region is destitute of trees. Two sharply defined forest types, which may be appropriately designated the pine type and the valley type, are recognizable. The pine type is that char-

[a] See Monthly Weather Review, September, 1888.

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acteristic of Pine Ridge in northwestern Nebraska. It extends across Sioux, Dawes, Sheridan, Cherry, Brown, and Keyapaha counties, and also occurs south of the North Platte River, in Scotts Bluff, Banner, Kimball, and Cheyenne counties. (See map.) Its chief tree is the rock pine, but red cedar is often present also. The rock pine occupies poor sandy soils or rocky ground in regions of moderate humidity. In this section it extends from the middle altitudes of the Rocky Mountains eastward along the slopes and ridges. The presence of red cedar among the pine is an indication of the great adaptability of this cedar, for it is also one of the constituents of the valley type.

The valley type is the common forest type of Kansas and Nebraska. With the exception of a small amount of red cedar, it is composed wholly of broadleaf species, and in the western parts of both States is confined closely to the water courses. Broadleaf species require more soil moisture than conifers, and in this region no good growth of them is found in any place where the roots can not reach nearly to permanent water.

Although species of the valley type are common in the draws and canyons of the Pine Ridge district, there is no real mixture of the two types of forest. A few pines and broadleaf trees grow together in the upper parts of the water courses, but, taken as a whole, neither type encroaches upon the domain of the other.

The pine type is of the greater economic importance where it occurs, but because of its wider distribution the valley type is of concern to a much larger number of people.

THE PINE TYPE.

The pine type of forest, as has been said, occupies two quite widely separated districts in Nebraska. These have no connection within the region here treated, though there is a junction farther west, in Wyoming. Pine Ridge proper is a ridge of low hills north of and parallel with the Niobrara River. It extends some distance into South Dakota and contains a fair growth of pine. The second pine region, lying from 60 to 75 miles south, is of less extent, but has the same general characteristics.

The scarcity of timber in the surrounding country has made severe demands upon the pine forests, which once yielded trees as large as 4 feet in diameter. The destruction of the pine began with the first settlers and has kept up until practically all that is fit for lumber is gone. Most of what remains can be used only for fuel and posts. A few specific instances will serve to illustrate how the timber has been cut.

On Pine Creek, south of Rushville, in Sheridan County, Nebr.,

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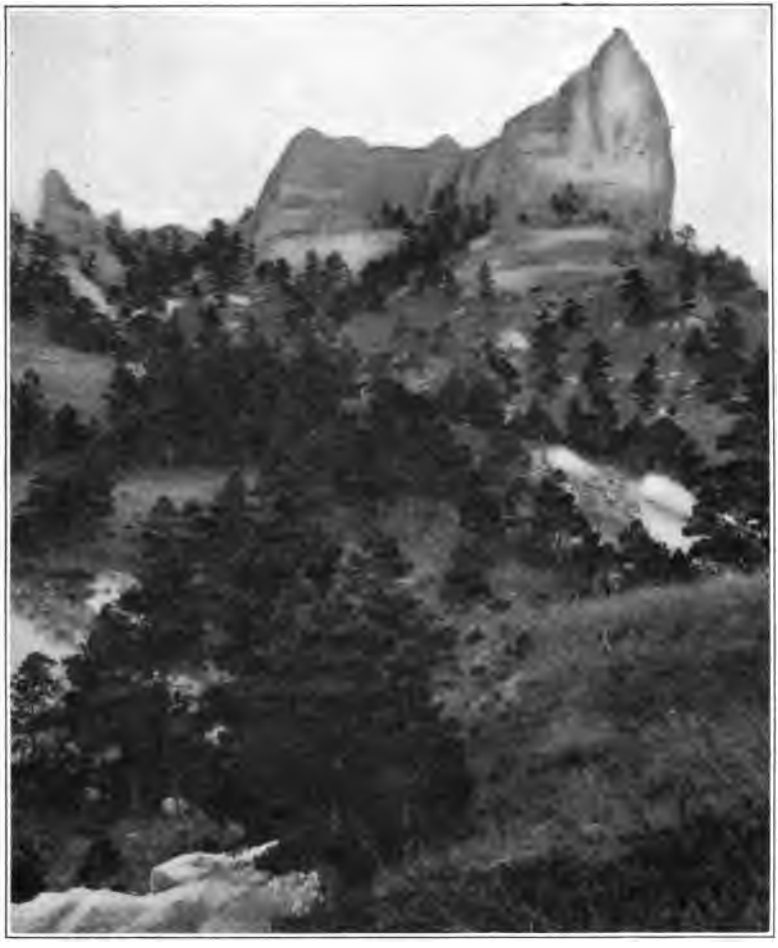

FIG. 1.—NATURAL PINE FOREST, DAWES COUNTY, NEBR.

FIG. 2.—TYPICAL SAND-HILL COUNTRY, THOMAS COUNTY, NEBR.

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the pine once covered a considerable area, but the only timber of any size now on the creek is on one farm, whose owner has taken some pains to preserve it. The pine extends up the creek a distance of about 2 miles from this farm, but scarcely any trees more than 6 inches in diameter are left. This was Government land until a few years ago, and people came from all directions and cut out every pine and cedar that would make even a post. On slopes where now not a pine taller than 6 feet can be found are many stumps ranging from 3 inches to 2 feet in diameter. Not only have the trees been removed, but even the greater part of the stumps have been grubbed up for fuel.

Not far from Harrisburg, in Banner County, several sawmills formerly operated, and large quantities of timber were cut in the latter eighties and early nineties. A few small mills also worked in the canyons south of Gering, in Scotts Bluff County. The lumber produced by these mills was used by the settlers in the construction of their houses and for many local purposes. The wagon bridge across the North Platte at Gering is floored with pine lumber of local production. Of the red cedar found with the pine a large amount was used for fence posts, but that, too, is nearly all gone. No mills are operating in the Platte region at present because the supply has ceased to exist, but on Pine Ridge a few small portable mills are yet working. Methods of cutting were wasteful. Often the tops of large trees, and even good logs, were left to rot on the ground, while much of the younger growth has been cut recently and used for poles and posts. In some instances rows of small trees were partially cut and bent over to the ground to form a rude fence.

The wholesale cutting which destroyed these forests was as justifiable as such a proceeding ever is, for the early settlers had few means of supplying their necessities; yet it would have been easy to maintain the forest by leaving sufficient seed trees and taking care not to injure the young growth. A great opportunity has been lost, yet the reproduction studies which come later in this report furnish evidence that, with proper protection, much good timber can be grown in the Pine Ridge regions before the end of the present century, while the larger trees now standing will attain a profitable cutting size in much less time.

MANNER OF GROWTH OF THE ROCK PINE.

Throughout most of the pine type the forest is now very open, so that the trees branch near the ground and do not form clean boles. Only occasionally in protected situations do good forest conditions occur. Large trees were originally abundant, but at present one is very rarely found that has a diameter of 3 feet. A few of the tallest

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trees are 80 feet in height. Larger trees, thriftier growth, and better reproduction are to be found north of the Niobrara than south of the North Platte. A well-preserved stump in Monroe Canyon, in Sioux County, measures 49 inches across the top and has 380 annual rings. Measurements of 10 pines on top of Scotts Bluff showed an average height of 21 feet and a diameter of 10.5 inches breasthigh, with a stand of about 20 trees to the acre. These figures indicate the size and density of much of the timber yet left in that section.

In a canyon some 15 miles southeast of Scotts Bluff is one of the few places where the timber has been unmolested in recent years, and as a result some excellent trees are developing. Ten thrifty trees at this place average nearly 18 inches in diameter breasthigh and 40 feet in height.

The better growth of the Pine Ridge region north of the Niobrara is shown by the measurements of 10 trees at the head of Willow Creek, in Dawes County. These averaged 57 feet in height and 25.4 inches diameter breasthigh. All are fine trees, with clean, straight stems. They stand on one-fifth of an acre, and there are several acres in this vicinity that average 50 equally good trees.

REPRODUCTION OF ROCK PINE.

The reproduction of pine on the areas included under the pine type is fairly good, though it is much less abundant south of the North Platte than on Pine Ridge. It was observed in 1901, however, when a field party of the Bureau of Forestry was at work in this region, that there was in many places a striking lack of seedlings less than 3 or 4 years old. To secure accurate information, as to the facts and their possible explanation, a number of detailed studies were made of the seeds and seedlings from different seed trees. In the case of five trees dry cones were collected and the seeds examined, with the following results:

Tree No. 1.—Diameter breasthigh, 7.7 inches; height, 22 feet. The tree was in healthy condition, and had made a height growth of 10 inches during the season,[a] but stood practically solitary, and the ground upon which its cones fell was covered with grama-grass sod, affording unfavorable conditions for the start of seedlings. Cones of various ages covered the ground beneath the tree. Those which had apparently fallen within the two previous years were counted and examined. They numbered 351, and were scattered over an area of 15 by 20 feet. The seed are usually dropped before the cone falls, but 212 seeds were obtained from the 351 cones, not one of which was capable of germinating. Although there was some indication of insect injury, careful examination showed that a majority of the

[a] The examination was made in August.

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seed never developed properly. The tree bore eleven cones which would mature the following fall. Not a seedling was found on the area covered by the cones.

Tree No. 2.—Diameter breasthigh, 11 inches; height, 25 feet. The conditions for the establishment of seedlings beneath it were poor, but somewhat better than in the case of tree No. 1. Upon an area of 20 by 22 feet were found 173 cones, containing 66 seeds, all of which had been injured by insects or had failed to develop. There was no recent reproduction. The only seedling pine on the area was 6 feet high.

Tree No. 3.—Diameter breasthigh, 30 inches; height, 65 feet. The tree was solitary, and was one of the oldest and largest trees in the neighborhood. The condition of the ground beneath it was more favorable to seedling growth than in the case of any other tree examined. An abundance of needles were distributed over the ground, and some low deciduous shrubs (*Symphoricarpus occidentalis* and *Rhus tribolata*) furnished shade favorable for germination. The ground was literally covered with cones of different ages. Upon an area of 40 by 45 feet were found 165 recent cones, containing 685 seeds, of which only 15, or less than 2 per cent, were sound. Eight seedling pines, from 6 inches to 2 feet high, were growing on this area. The tree bore no cones set the previous year, but an abundance set the year of the examination which would mature the following season.

Trees No. 4 and No. 5.—No. 4, diameter breasthigh, 18 inches; height, 50 feet. No. 5, diameter breasthigh, 19 inches; height, 55 feet. These two trees stood about 50 feet apart, on a northwest slope, and dropped their cones over a contiguous area measuring 50 by 70 feet. Judging from the number of fallen cones, they are prolific bearers. The ground is covered with dense grama-grass sod. From 240 cones examined, 546 seeds were obtained, of which only 5 were sound. A great many had been destroyed by worms. Tree No. 5 had a great many cones of the second year before still on it. A number of these were picked and examined, but no good seeds were found in them. The tree bore no cones of the previous year, but a great many which would mature the following year. There were no seedlings beneath these two trees.

Green cones were picked from three other trees and the seeds examined. The results were as follows:

Tree No. 6.—Diameter breasthigh, 13.5 inches; height, 25 feet. The tree was in vigorous condition, and had made a height growth of 10 inches during the season. The cones were large and apparently healthy. Twenty, taken from various parts of the tree, were found to contain 1,307 seeds, of which 191, or 14.6 per cent, were sound. The majority of the imperfect seeds seemed to have failed of fertiliza-

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tion. Ten of the 20 cones were infested with insect larvæ, and in one cone 6 of these were found and every seed had been destroyed.

Tree No. 7.—Diameter breasthigh, 33 inches; height, 67 feet. This tree was cut and was found to be over 300 years old. It was heavily loaded with green cones, which were much smaller than those of No. 6, and, as a rule, contained only 1 seed to each scale. Twenty cones yielded 569 seed, of which 120, or 21 per cent, were sound. No indication of damage by insects was discovered, but a considerable number of the seeds were aborted.

Tree No. 8.—Diameter breasthigh, 10 inches; height, 38 feet. This was a small, thrifty tree in a small group. The opportunity for fertilization of the seed was therefore better than in the case of the others examined. The tree bore 14 green cones, 10 of which were examined and found to contain 377 seeds, of which only 3 were sound. The poor seeds were undeveloped; no evidence of insect damage appeared. Conditions for seeding under this tree were fair, but no seedlings were growing.

The following table presents the numerical results of the preceding individual studies:

TABLE I.—*Number and percentage of good seeds taken from cones of individual trees.*

FRESH CONES FOUND BENEATH THE TREE.

Tree No.	Diameter breast-high.	Height.	Seed-bed area.	Cones.	Seeds.	Good seeds.	Per cent of good seeds.
	Inches.	*Feet.*	*Sq. feet.*				
1	7.7	22	300	351	212		
2	11.0	25	440	173	66		
3	30.0	65	1,800	165	685	15	2
4	18.0	50	3,500	240	548	5	1
5	19.0	55					

GREEN CONES PICKED FROM THE TREE.

Tree No.	Diameter breast-high.	Height.	Cones.	Seeds.	Good seeds.	Per cent of good seeds.
	Inches.	*Feet.*				
6	13.5	25	20	1,307	191	14.6
7	33.0	67	20	569	120	21.0
8	10.0	38	10	377	3	.8

It appears, then, that out of a total of 1,509 seed gathered from fallen cones, only 20, or 1 in 75, were good, and that out of 2,253 seed from green cones 314, or not quite 1 in 7, were good. While in some cases insect injury was responsible for a large part of the defective seed,

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FIG. 1.—ORDINARY REPRODUCTION OF ROCK PINE, SIOUX COUNTY, NEBR.
Much denser stands exist in many other places.

FIG. 2.—YOUNG RED CEDAR ON THE BLUFFS, HOOKER COUNTY, NEBR.

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the chief cause must be found in the failure of the seed to develop. Whether or not this in turn is due to the cutting of neighboring trees and a consequent decrease in the opportunity of fertilization can not be said with certainty.

It should be remarked, however, that the lack of young seedlings immediately beneath the trees does not show that the entire crop of the corresponding years failed, since a large part of the seed are released before the cone falls and may be borne a considerable distance by the wind before they reach the ground.

Notwithstanding the lack of very small seedlings which was observed, and the large proportion of defective seed found in the cones of three successive seasons, there is no reason to believe that a permanent deficiency in reproduction is likely. The presence of many seedlings 4 years old and over militates against such a conclusion. It is well known that the seed production of trees is generally periodic and that heavy crops are usually several years apart. And even in years of abundant seed production germination may fail for want of the necessary attendant conditions.

The precipitation of this region is scanty—only about 15 inches annually on the average—and it is also extremely variable. Thus it may easily happen that plenty of seed are set in a favorable season, but the second year required to mature them is dry and they are lost or the seed may mature, yet reach a soil so inhospitable that they can not germinate. In other words, plentiful reproduction is dependent upon a succession of moderately moist seasons or upon the coincidence of a good seed year with fovarable conditions for germination. In spite of these difficulties, however, there is no doubt of the ability of the pine to reproduce itself in the course of time, provided a sufficient number of seed trees are left and the ground is not exposed to fire nor overgrazed.

In numerous situations good reproduction can be found. This is especially true of north and east slopes, where there is always more moisture than on other exposures. The best conditions for the production of pine seedlings are found where there is no sod, but a loose, bare soil or one covered lightly with leaves and litter. North of the Niobrara conditions are generally more favorable and the seedling growth better than south of it. In Sioux County, for instance, the reproduction on many areas is very satisfactory. Young seedlings 5 years old and over were noted in great numbers at the base of the rocky cliffs, on the hillsides, and even in the prairie sod. On a northwest exposure, at the base of a precipitous bluff from 50 to 75 feet high, 903 young pines from 3 inches to 22 feet in height were found on an area 45 by 47 feet. The seeds from which these grew must have

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been blown from trees on the opposite side of the canyon, not less than a quarter of a mile distant. On another area 15 by 24 feet, in Monroe Canyon, 291 trees, ranging from 4 inches to 5 feet in height, were counted. A plot 20 by 25 feet, on a steep north slope in Sowbelly Canyon, contained 380 seedlings from 6 inches to 6 feet in height. This plot is an excellent seedbed, as there is plenty of humus in the soil and a fair covering of leaves on the ground. The densest growth observed was at the head of Hat Creek. An area of 1 square rod at this place contained 317 seedlings, or at the rate of over 50,000 per acre. This is an unusual case, but could be duplicated on several small plots.

RATE OF GROWTH OF ROCK PINE.

In order to determine the rate of growth of the young pine, measurements were made in various localities. Table II gives the results for representative Pine Ridge situations.

TABLE II.—*Average height growth of young rock pine on Pine Ridge.*

Place.	Trees measured.	Age.	Diameter at ground.	Height.	Height growth, 1901.
		Years.	*Inches.*	*Feet.*	*Inches.*
Crawford, Dawes County, Nebr	12	10	1.8	2.4	4.5
Bordeaux, Dawes County, Nebr	15	10	1.1	2.8	5.5
Belmont, Dawes County, Nebr	12	12	1.5	3.1	8.0
White Clay Creek, Dawes County, Nebr	12	13	1.3	3.6	3.9
Valentine, Cherry County, Nebr	10	14	1.8	4.1	10.0
Georgia, Cherry County, Nebr	10	17	2.0	4.6	11.0
Irwin, Cherry County, Nebr	10	19	2.2	3.9	7.0

None of these trees show a remarkable rate of growth; indeed, most of them are making branches rather than stem, yet all are now past the period of early youth, when growth is naturally slow, and promise to develop much more rapidly in the future.

OCCURRENCE OF THE RED CEDAR.

The red cedar has been so completely cut out that it is rare to find a thrifty tree of merchantable size. Young growth is abundant in many places, but the older trees are extremely scrubby. The latter are found on the slopes and among the rocks; many are partially dead, and the form of all is inferior. They have a multitude of branches and very little clear length, although their low, bushy form gives some of them very large diameters. A cedar in Banner County, 15 miles southwest of Gering, which has long been used as a Government landmark, is 5 feet in diameter breasthigh, and has a clear

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length of 12 feet and a height of 40 feet. It is comparatively healthy and is still growing slowly. Another cedar in Banner County, about 7 miles northwest of Ashford, has a diameter breasthigh of 4.8 feet and a height of 35 feet, with only 8 feet of clear length. In general, measurements made of individual trees in various localities indicate a fair rate of growth.

There is much less red cedar along Pine Ridge than south of the North Platte. In Sioux County, for instance, very few living trees are found, though there are some old, decaying trees on the steep sides of the canyons. The early settlers say that the cedar was formerly more abundant, but cutting has been so close that very few good trees are left. Cedar was once very plentiful in the canyons along the Niobrara River, and at present there are excellent stands of young trees in many places which, if protected, will develop into valuable timber.

REPRODUCTION OF THE RED CEDAR.

Where seed trees exist the reproduction of the red cedar is generally good, and not rarely the number of young cedar seedlings is relatively much larger than that of the pine, and they are of all ages. This may be accounted for by the facts that the cedar is a prolific seed bearer, and that its seed years are much more frequent than those of the pine. It is also to be observed that where all the well-developed cedar trees have been cut, old, scrubby, half-dead veterans are often left, which bear seed abundantly. The young growth seems to be uniformly in a healthy condition, and sometimes forms very dense stands. In a Banner County canyon a plat 8 by 43 feet contained 206 trees from 18 inches to 10 feet high—a rate of more than 26,000 to the acre.

There is evidence that in many cases cedar is replacing pine after cutting. For example, on an area of 6.16 acres in Muddy Gulch, on which 37 pine stumps, averaging 6.4 inches in diameter, and 77 cedar stumps, averaging 6.1 inches in diameter, were counted, of growing trees 3 inches or more in diameter 177 were pine and 65 cedar, but of those less than 3 inches in diameter only 237 were pine, while 1,010 were cedar. In other words, the proportion of pine to cedar in the large trees and stumps combined is about 3 to 2, while in the young growth it is less than 1 to 4. One-third of an acre in Banner County showed 10 cedar and 13 pine stumps, and 1 large living cedar and 17 pines, but 192 cedar seedlings to 45 pine seedlings.

Undoubtedly birds are the principal agency in disseminating the cedar seed throughout this region. Underneath one pine tree in

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Muddy Gulch 17 little cedars were found, though there were no old cedar trees in the vicinity.

ENEMIES.

The common enemies of young trees everywhere are fire and stock, and the pine and cedar of Nebraska have not escaped their ravages. Fires have passed over much of the region at various times, and unquestionably have played an important part in determining the character of the forest. The actual damage to the old trees may have been less than in many forest regions, yet there is little doubt that without the fires the present pine areas would have been larger and the stand less open. Since the settlement of the country fires have been checked, and testimony is unanimous that because fires are less frequent the sand hills are better grassed and the sand much more stable now than it was in the early days.

Reproduction of the forest is hindered to a considerable extent by stock. The entire region is grazed by horses and cattle, principally the latter. Much of the young growth, however, is on steep slopes, where, because of the precarious footing and because of the unpalatable grass which grows in such situations, stock does not often go. In the bottoms of the draws and canyons, where the grass is better and water often appears, it is not uncommon to find the reproduction wholly ruined. In sandy soils the trampling of stock is extremely injurious to young trees, and there is little hope for good reproduction so long as grazing is unrestricted.

In some sections insects are an additional menace to the pine. Now and then a tree is killed by bark borers, and considerable harm results from the work of worms in the cones. But by far the worst pest is the tip-borer. This insect, in the larval form, destroys the terminal buds of the leading shoots and dwarfs the young pines until they can never make a growth of any value. During the season of 1901 this insect was common throughout the Pine Ridge region. The greatest damage was done in Dawes County and eastward along the Niobrara. In some stands of young pine, otherwise in fine condition, nearly all the terminal buds readily break off and crumble between the fingers.

A striking illustration of the effect of a number of years' work of this insect was afforded by ten trees found growing in a canyon in Sheridan County. They were in a sandy soil on a north exposure and would evidently have made good trees had they not been attacked by the tip-borer. Although these trees average 23 years of age, their average diameter at the ground was only 1 inch, and their average height but 32 inches. Their individual measurements are shown in the following table:

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TABLE III.—*Young pine injured by tip-borer.*

Tree No.	Age at ground.	Diameter at ground.	Height.	Height growth, 1901.
	Years.	*Inches.*	*Feet.*	*Inches.*
1	35	1.5	2.5	1.0
2	35	1.4	4.3	1.0
3	17	.4	.6	1.0
4	33	1.2	5.0	1.0
5	9	.5	1.5	.5
6	20	.5	1.8	.5
7	10	.5	.9	3.0
8	30	.9	2.5	.3
9	20	1.0	3.3	1.4
10	21	1.4	4.6	4.0
Average	23	1.0	2.7	1.4

THE TENDENCY TO FOREST EXTENSION.

In all parts of the pine type there is at present abundant evidence of a strong tendency toward the natural extension of the pine and cedar forest. It is a tendency which, if encouraged, will eventually result in a great addition to the material resources of western Nebraska. The pine is at present confined almost entirely to the slopes and ridges. This rougher country, with its many exposures of bare soil, offers a better chance for the seed to catch and germinate, yet instances are not lacking in which abundant reproduction is found in the sod at the beginning of the upland level. In former days, when fires were frequent, they burned more fiercely in the dense growth of grass on the upland than in the scattering vegetation of the breaks, and thus aided in restricting the pine to the rough situations.

While the existence of small bodies of detached pine far to the east of the present pine region in Nebraska affords ground for the belief that at some former time pine was distributed much more widely over the State than at present, the tendency now is toward extension. It is certain that a large area contiguous to that which now contains good pine and cedar is equally well adapted to its growth as that which it now occupies.

Another observation was made within the present forest areas which indicates that present conditions are more favorable to tree growth than they were a hundred years or more ago. It is that trees 50 to 80 years old have in many instances grown more rapidly than older trees did during the corresponding period of their lives. Stem analyses of a number of trees were made both north of the Niobrara and in the Platte River section, and all showed that the younger

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trees have grown more rapidly in both diameter and height throughout their entire lives than did the older trees.

Tables IV, V, and VI are compiled from these stem analyses, and while each table is based upon only a few trees, all point in the same direction, furnishing strong corroborative, though not conclusive, evidence. Analyses of small seedlings chosen from representative situations also show that they are growing faster in height than did the older trees and at practically the same rate as the younger ones.

TABLE IV.—*Average diameter at ten-year periods of solitary rock pines at Muddy Gulch, Scotts Bluff County, Nebr.*

Age.	Diameter at stump inside bark.		Age.	Diameter at stump inside bark.	
	60-year-old trees.	110-year-old trees.		60-year-old trees.	110-year-old trees.
	Inches.	*Inches.*		*Inches.*	*Inches.*
10 years	1.7	1.1	70 years		7.9
20 years	3.5	2.1	80 years		8.8
30 years	5.2	3.3	90 years		9.8
40 years	6.8	4.5	100 years		10.7
50 years	8.0	5.7	110 years		11.4
60 years	8.9	6.9			

TABLE V.—*Average diameter at ten-year periods of the larger trees in a stand of rock pine at Monroe Canyon, Sioux County, Nebr.*

Age.	Diameter at stump inside bark.		Age.	Diameter at stump inside bark.	
	50-year-old trees.	110-year-old trees.		50-year-old trees.	110-year-old trees.
	Inches.	*Inches.*		*Inches.*	*Inches.*
10 years	1.9	1.2	70 years		6.7
20 years	3.7	2.4	80 years		7.2
30 years	5.4	3.4	90 years		7.7
40 years	6.7	4.4	100 years		8.0
50 years	7.9	5.3	110 years		8.3
60 years		6.0			

TABLE VI.—*Average height at ten-year periods of solitary rock pines at Muddy Gulch, Scotts Bluff County, Nebr.*

Age.	Height.		Age.	Height.	
	85-year-old trees.	185-year-old trees.		85-year-old trees.	185-year-old trees.
	Feet.	*Feet.*		*Feet.*	*Feet.*
10 years	2.8	2.4	60 years	26.2	19.2
20 years	6.5	4.8	70 years	29.8	23.0
30 years	11.1	7.2	80 years	33.6	26.0
40 years	16.6	10.6	90 years		29.6
50 years	22.0	15.0			

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The rock pine and red cedar do well together and form a valuable forest. The cedar will grow in as dry situations as the pine, but it is also often found in the bottoms of the canyons, where there is too much moisture for the pine. The pine constitutes the main forest, while the cedar fills up the interstices.

On many areas belonging to the pine type the natural replacement or extension of the forest will be slow, because the trees which might furnish seed have been destroyed, but in others it may easily be accomplished. If the owner of pine land in western Nebraska will leave from 5 to 10 trees on each acre to furnish seed, and will protect the young seedlings from fire and stock, he will eventually have a young forest in the place of the old. If he wishes to enlarge the forest area it may often be done by sparing the old trees on the windward side of a vacant field until their seeds have produced a proper stand of young trees. In this case, as always, the area must be protected against fire and stock.

THE VALLEY TYPE.

GENERAL FEATURES.

The valley type of forest is confined entirely to the valleys of water courses and draws or their adjacent bluffs (see Pl. IV), and consists wholly of broadleaf species, with the exception of a few individuals or of small areas of red cedar. No body of timber of this type is known to grow on the uplands of western Kansas and Nebraska, though scattering trees are often found in the heads of the draws almost to the upland level. In the valleys there are occasionally areas of a few acres in extent on which true forest conditions prevail, but the general form is that of a narrow belt of trees a few rods in width, holding closely to the banks of a stream or the bottom of a draw. The type is thus closely associated with the best farm lands of the region.

The trees generally are low, with spreading crowns, though dense stands sometimes occur in moist situations which produce good, clear trunks. Cottonwoods may attain a height of 75 feet, but the maximum height of the other species is in the neighborhood of 50 feet, while many mature trees do not grow even that high. Diameters, too, are mostly small, except in the case of cottonwood, which frequently attains a diameter of 3 to 4 feet, and sometimes over 5 feet. A green ash at Hays, Kans., is 44 inches in diameter 2 feet above ground, and a white elm on Eagle Creek, near Paradise, is 62 inches in diameter at breastheight, but these are exceptional cases. Aside from the cottonwoods, the average diameter of the broadleaf species of western Kansas and Nebraska is probably not far from 6 inches.

The Cimarron, Arkansas, Smoky Hill, Republican, and Platte

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rivers are preeminently sandy streams with shifting beds, so that timber growth is either wholly absent from them over long stretches or consists only of scattering cottonwoods and willows. As previously mentioned, the smaller streams which are less sandy support other species, principally green ash, white elm, hackberry, and box elder.

In Kansas, as far west as the one hundredth meridian, nearly every stream has its fringe of timber, and there is considerable diversity in species; but both the quantity and variety decrease westward, until at the Colorado line timber is very scarce, and occurs mainly on the Smoky Hill and Arkansas rivers. Along the tributaries of the former stream, in Russell County, near the center of the State, there are found cottonwood, willow, red and white elm, black walnut, bur oak, hackberry, box elder, green ash, red cedar, red mulberry and wild china; while in Wallace County, on the western border, there are only a few groves of cottonwood and willow. The best westward extension of timber in Kansas is on Beaver Creek, in Rawlins County. The creek is bordered by a thriving growth of green ash, with a lesser number of several other species. The timber reaches to some distance above Atwood, not far from the point where the bed of the stream first carries permanent water. (See Table XI.)

In Nebraska there is likewise a progressive lessening in the number of species as one goes westward, until the foothill region is reached, when the increased altitude causes the appearance of Rocky Mountain forms. In Buffalo County, for instance, the species found are bur oak, green ash, box elder, white elm, hackberry, cottonwood, and willow. Farther west, in Deuel County, the box elder, elm, and oak are missing, while in Scotts Bluff County occur box elder, several willows, lanceleaf, narrowleaf, and common cottonwood, green ash, hackberry, valley mahogany, western birch, western serviceberry, and dwarf maple. Sioux County, in the extreme northwest, has the greatest variety of trees and shrubs of any county covered by this report.

The trees of the valley type are commonly quite vigorous, though many of them are relatively short lived. Considerable damage is done by borers, and in some localities the ash is badly injured by them as well as by heart rot. Galls on the twigs of various species are occasionally abundant, and leaf-eating insects do more or less harm. Many of the broadleaf trees in the draws and canyons of Pine Ridge are in bad condition. Growth is slow and scrubby, and dead limbs and tops are common. Scars from old burns are found, but the apparent reason for the general unhealthfulness is that the cutting of the pine of the higher land has lessened the amount of water about their roots.

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FIG. 1.—VIEW ALONG THE NIOBRARA RIVER IN SHERIDAN COUNTY, NEBR.
The timber is white elm, green ash, cottonwood, and almondleaf willow.

FIG. 2.—THE USUAL TYPE OF FOREST ALONG CREEKS IN KANSAS AND NEBRASKA.
The trees are white elm, green ash, hackberry, and boxelder.

FIG. 3.—YOUNG COTTONWOODS ALONG THE ARKANSAS RIVER, DODGE, KANS.

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The cutting of timber in the valley type of forest has been much less pronounced than in the pine type. Considerable cutting has taken place, it is true, and many a magnificent cottonwood on the Platte and the Arkansas disappeared with the advent of the railroads, while a clean sweep was often made where red cedar existed; but the total number of trees to-day is probably much greater than when the white man first came, though the average size of the trees is smaller and their average age less. This points directly to the possibilities of natural extension where fires and grazing are controlled.

Commercial returns are secured only from posts, poles, and firewood. Very little timber is cut for sale, however, and the man who has timber on his place is benefited chiefly by the uses which he makes of it for domestic purposes and the protection afforded to stock and buildings. This is no small consideration in a region where lumber and posts are high-priced and coal expensive. With the exception of the ash, the more valuable species have a restricted range, but in the lack of something better wood of any kind is gladly used.

DENSITY OF GROWTH.

Measurements were made in various localities to determine the density of typical areas of forest growth, the trees on a sample acre being counted and measured in each case.

The figures obtained from five typical acres are given in Tables VII to XI. These illustrate well the better class of forest growth along the streams in western Kansas and Nebraska. It is not to be supposed that each stream contains timber throughout its entire length such as that found on the sample areas. These areas represent either the average or the best growth for the region. A short distance away on the same stream there may be no trees at all.

TABLE VII.—*Trees on a sample acre on Elm Creek, at Medicine Lodge, Kans.*

Species.	Trees.	Diameter breasthigh.	
		Minimum.	Maximum.
		Inches.	*Inches.*
White elm	43	6	19
Hackberry	5	4	6
Red mulberry	4	5	8
Total	52		

These are average trees on a flat just south of Medicine Lodge. The land is pastured, and the forest is very open and scrubby. Despite the nearness to water, the trees do not average over 30 feet high and contain numerous dead branches. There is neither underbrush nor reproduction, and the ground is well grassed. This condition is caused by constant grazing.

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TABLE VIII.—*Trees on a sample acre on Pawnee Creek, at Burdette, Kans.*

Species.	Trees.	Diameter breasthigh.	
		Minimum.	Maximum.
		Inches.	*Inches.*
Green ash	54	3	21
White elm	39	1	22
Hackberry	67	1	16
Wild china	2	2	2
Total	162		

Conditions in this locality are very good. In places the trees extend back from the creek a distance of 200 yards. They also ascend the side draws, and tend to spread out a little on the upland, where cattle are not allowed.

TABLE IX.—*Trees on a sample acre on Prairie Dog Creek, near Almena, Kans.*

Species.	Trees.	Diameter breasthigh.	
		Minimum.	Maximum.
		Inches.	*Inches.*
Boxelder	132	3	27
Green ash	122	3	11
White elm	28	2	15
Almondleaf willow	12	7	13
Cottonwood	4	10	26
Total	298		

These trees are growing in heavy soil. Their condition is very good, and the stand is unusually dense.

TABLE X.—*Trees on a sample acre on Beaver Creek, at Atwood, Kans.*

Species.	Trees.	Diameter breasthigh.	
		Minimum.	Maximum.
		Inches.	*Inches.*
Green ash	224	1	11
Almondleaf willow	15	4	14
Hackberry	3	4	6
Total	242		

This is a fair average acre for much of the forest growth of this section. The ash trees are young and probably do not average more than 5 inches in diameter, but they are doing very well and should develop into valuable timber.

Farther down the creek, at Beaver City, Nebr., the type changes, and is composed principally of boxelder, as shown by Table XI.

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TABLE XI.—*Trees on a sample acre on Beaver Creek, at Beaver City, Nebr.*

Species.	Trees.	Diameter breasthigh.	
		Minimum.	Maximum.
		Inches.	*Inches.*
Boxelder	91	3	15
Green ash	21	2	8
White elm	18	2	19
Almondleaf willow	2	2	12
Total	132		

RATES OF GROWTH.

Owing to the fact that little cutting is now being done on this type, not many measurements of the rate of growth can be made, but the figures given in Tables XII to XV will serve to show how fast the four chief species increase in diameter in various localities. These figures should be used with caution, however, for they belong to trees as they happened to be found, and represent widely different conditions of growth.

TABLE XII.—*Diameter growth of white elm in various localities.*

Place.	Age.	Diameter at stump outside bark.	Time required to grow 1 inch.	
			Individual trees.	Average.
	Years.	*Inches.*	*Years.*	*Years.*
Pawnee Creek, Burdette, Kans.	15	7.2	2.1	1.9
	18	10.8	1.7	
	22	10.3	2.1	
	25	11.5	2.2	
	25	12.4	2.0	
	30	23.2	1.3	
Walnut Creek, Bazine, Kans.	21	10.5	2.0	2.5
	30	9.1	3.3	
	37	17.6	2.1	
	68	25.0	2.7	
Landons Creek, Russell, Kans.	33	15.0	2.2	2.3
	37	17.5	2.1	
	50	18.5	2.7	
Bow Creek, Logan, Kans.	26	8.2	3.2	2.8
	31	12.4	2.5	
Prairie Dog Creek, Norton, Kans.	23	7.0	3.3	3.5
	23	8.8	2.6	
	27	7.5	3.6	
	28	6.8	4.0	
	29	7.5	3.8	

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TABLE XIII.—*Diameter growth of green ash in various localities.*

Place.	Age.	Diameter at stump outside bark.	Time required to grow 1 inch.	
			Individual trees.	Average.
	Years.	*Inches.*	*Years.*	*Years.*
Pawnee Creek, Burdetto, Kans	19	6.2	3.1	2.9
	23	7.2	3.2	
	24	9.6	2.5	
Walnut Creek, Bazine, Kans	20	6.0	3.3	3.5
	21	6.7	3.1	
	26	9.0	2.9	
	28	9.3	3.0	
	33	6.1	5.4	
Landons Creek, Russell, Kans	26	10.5	2.5	3.1
	30	7.5	4.0	
	31	10.7	2.9	
Bow Creek, Logan, Kans	21	6.8	3.1	3.6
	23	6.0	3.8	
	24	6.4	3.8	
	33	10.8	3.0	
	37	8.6	4.3	
Wolf Creek, Waldo, Kans	32	10.5	3.0	3.0
	35	12.5	2.6	
	46	14.5	3.2	

TABLE XIV.—*Diameter growth of hackberry in two localities.*

Place.	Age.	Diameter at stump outside bark.	Time required to grow 1 inch.	
			Individual trees.	Average.
	Years.	*Inches.*	*Years.*	*Years.*
Pawnee Creek, Jetmore, Kans	22	4.3	5.1	5.2
	24	4.2	5.7	
	25	5.4	4.6	
	25	4.4	5.7	
	27	5.0	5.4	
	33	6.9	4.8	
	37	8.1	4.6	
	38	4.8	5.8	
Walnut Creek, Bazine, Kans	18	5.4	3.3	3.4
	60	16.7	3.6	

TABLE XV.—*Diameter growth of bur oak near Alton, Kans.*

Age.	Diameter at stump outside bark.	Time required to grow 1 inch.	
		Individual trees.	Average.
	Inches.	*Years.*	*Years.*
35 years	6.4	5.5	3.8
35 years	9.5	3.7	
36 years	13.2	2.7	
36 years	10.0	3.6	
37 years	10.0	3.7	
38 years	11.3	3.4	

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REPRODUCTION.

The common broadleaf trees of the valley type are able to reproduce well, but the general absence of young growth is very striking. In many places where older trees are abundant, one will look long before he finds anything under 2 inches in diameter, or even a 1-year-old seedling. The cause of this can be given in a single word—stock. The stockman always locates on a stream, if possible, and of course includes the stream and its timber in his pasture. The farmer of the plains usually has a number of horses and cattle, and his invariable rule is to farm his best land and to pasture the rest. Water and shelter are essential to the stock, and neither ranchman nor farmer thinks he can afford to keep his herds from the draws and creeks for the sake of the timber that will eventually get a foothold if given the opportunity. On thirty-one sample areas, measured in various representative situations in western Kansas, the reproduction can be called good in but six instances, and only fair in six more, while it is very poor in the remaining nineteen. All of these nineteen areas are pastured. Where stock is excluded, it is not uncommon to find hundreds of small ash, hackberry, and other seedlings, while on the sand bars of the Platte and the Arkansas dense stands of young cottonwoods often occur. These facts are evidence that unrestricted grazing limits the reproduction of the trees in the valley type and prevents its extension.

Plate V makes this very clear. Figure 1 shows a growth of cottonwood, elm, and shrubs coming in on the Saline River, in Russell County, Kans., where stock has been excluded most of the time for the past twenty years. Figure 2 is a view on the same stream half a mile distant, where not a single shrub is visible. Soil conditions are identical in the two situations, and cattle alone are responsible for the difference.

A progressive ranchman living on the Smoky Hill River, who appreciates the value of trees and has some thought for the future, fenced half a mile of the river bed out of his pasture six years ago. Cottonwoods and willows have started under the protection given them, and promise to make a good grove. When the trees are large enough to withstand the presence of cattle this area will be turned back into the pasture and a similar adjoining one fenced out. In this way a fair amount of timber will gradually be secured without losing the use of much land at any one time.

The red cedar in the valley type does not suffer from grazing to the same extent as the broadleaf species. Cattle do not eat the seedlings, and from the fact that seedlings frequently grow on hillsides where they escape trampling, the reproduction is excellent. The cedar is a prolific seed bearer, though worms destroy some seeds

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and still more fail to develop properly, so that the proportion of poor seed is sometimes very high.

The best reproduction of red cedar in Nebraska, in the valley type, is probably on the Dismal River. Along the lower half of the South Fork of the Dismal River both red cedar and green ash were formerly exceedingly abundant. Although most of the large trees have been cut, and cattle and fire are doing much injury to what is left, thousands of young cedar, from a few inches to 15 feet in height, are to be seen, besides much healthy sprout growth of ash.

The cedar is mostly on the bluffs and in the lateral canyons on the south side of the river. Where undisturbed by fire and cattle the young growth is thriving and tends to spread up to the tops of the bluffs. Above any of the larger trees fine young cedars, from 1 to 4 feet in height, can be found growing isolated in the bunch grass.

Around the north side of one old, scrubby tree, on a steep north exposure, 23 young trees from 2 inches to 4 feet high were counted, and in the bottom of one of the canyons a circular space 9 feet in diameter contained 36 cedars between 4 and 15 feet high. There is every reason to believe that with protection a very valuable growth of timber could be secured.

The following table illustrates the rate of growth of young cedar in this region. The trees grew on a north slope in very sandy soil.

TABLE XVI.—*Young red cedar on the Dismal River.*

Tree No.	Age at ground.	Diameter at ground.	Height.	Height growth.	
				1900.	1901.
	Years.	*Inch.*	*Feet.*	*Inches.*	*Inches.*
1	9	0.5	3.3	4.0	5.0
2	6	.2	1.1	4.0	2.0
3	10	.4	3.5	6.0	6.0
4	10	.3	2.1	2.0	2.0
5	10	.2	1.7	3.0	5.0
6	14	.4	3.1	4.0	4.0
7	18	.7	3.7	4.0	2.0
8	3	.1	.4	1.0	1.0
9	11	.5	4.0	2.0	6.0
10	11	.6	5.1	5.0	5.0
Average	10	.4	2.8	3.5	3.8

The original amount of red cedar in Kansas was much less than in Nebraska, and the few trees that are left are mostly inferior individuals, scattered about over the bluffs. Reproduction is generally poor. The best original growth was on Cedar Creek, in South County, where many thriving little trees may now be found. A few striking clumps of old cedar are still standing on the bluffs of Big

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FIG. 1.—THRIVING YOUNG GROWTH OF WHITE ELM, COTTONWOOD, AND SHRUBBERY WHERE CATTLE HAVE BEEN EXCLUDED. SALINE RIVER, RUSSELL COUNTY, KANS.

FIG. 2.—PASTURED BOTTOM LAND, ONLY ONE-HALF MILE FROM WHERE FIG. 1 WAS TAKEN.

The absence of trees is due entirely to cattle.

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Creek, in Russell County, and here also the reproduction is good, though necessarily limited.

HOW FOREST EXTENSION IS BROUGHT ABOUT.

The steps by which forestation begins are often apparently insignificant and unobserved. On the streams, the sand-bar willow (*Salix fluviatilis*) and the false indigo (*Amorpha fruticosa*) play an important part. Their roots hold the banks and bars from shifting until tree species can get a foothold. The sand-bar willow is particularly well adapted to this end. Its roots spread many feet just beneath the surface of the sand, and a new shoot is produced every few inches. After the sand is fixed and other species started the willow dies, but its mission has been fulfilled. Its seed is carried by the water as well as the wind, so that the same flood which makes a sand bar often seeds it to the tree which will redeem it.

In heavier soils, other shrubs are forest forerunners. The smooth sumac (*Rhus glabra*), the wolfberry (*Symphoricarpos occidentalis*), and the wild plum (*Prunus americana*) are among the species which grow in clumps and are able to win in the fight against grass. Favorable conditions for the germination of tree seeds are thus created, while the shrubbery protects the young seedlings until they are of considerable size.

The one thing which, above all others, makes for improved conditions on the plains, and gives assured hopes for better tree growth in the future than in the past, is the cessation of fires. Before the country was settled, fires were both frequent and extensive. Whether originating from some neglected camp fire, a flash of lightning, or set by the Indians, they swept over vast areas unchecked and left nothing but a barren waste behind. Only the trees along the streams could survive, and, at best, make a stunted, scrubby growth. Reproduction was extremely uncertain, owing to the repeated destruction of the small seedlings, and grass gained the ascendency over all other forms of vegetation.

With the nearly complete stoppage of fires since the country has been permanently settled, conditions are greatly improved. It is a matter of common knowledge among the stockmen of western Kansas and western Nebraska that the grasses are changing with noticeable rapidity, and that the species common in the eastern part of both States are working their way westward. The writer has in mind specific tracts of land in western Kansas on which, in less than twenty years, the predominating grass has changed from the "buffalo grass" of the arid plains to the "blue stem" of farther east. It is perfectly safe to assume that a change in conditions so radical as this is favorable to forest extension. Several tree species have succeeded, under the most adverse circumstances, in forcing their way into the very

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heart of the plains by following up the water courses tributary to the Missouri River. It is therefore quite certain that with protection they will in the future steadily win new territory.

VALUE OF FOREST EXTENSION.

The study that is here reported makes it clear that the forests of western Kansas and Nebraska are much more restricted in area and poorer in character than they need be. In many localities soil and climate are hospitable to trees, and enough has been learned about the reproductive powers of the various native species to warrant the assertion that where old trees capable of furnishing seed exist, in such places forests may be established at no greater cost than is entailed in keeping cattle and fire from the land.

The pine areas are commonly of little value for agriculture, and the question is simply whether they will yield a higher rent in forest or as stock range. That it takes a long while to grow trees fit for any practical purpose is true, yet a region without trees can never be permanently prosperous, and few farmers can do better for their property than by establishing groves upon it. The Government is so well convinced of the practicability of growing trees from seed in this section that it has created two forest reserves, containing 208,000 acres, in the sand hills of Nebraska, and proposes to plant trees upon them. There are now about 2,500,000 pine seedlings in the nurseries at Halsey, Nebr., and young trees have been planted in their permanent places in the near-by hills. A similar sand-hill reserve of 97,280 acres has recently been established near Garden City, Kans., for the same purpose.

Definite figures regarding the profitableness of maintaining forests in this region can not be given because the growth has been so rarely fostered. It is possible, however, to learn from the data given in the foregoing tables that on pieces of land now given over to stock a stand of trees can be obtained in a comparatively few years whose value will exceed the accumulated rents as pasture. Thus, according to Table X, in favorable situations white elm grows at the rate of 1 inch in diameter in about two and a half years. This means that it takes thirty years to produce a tree 12 inches in diameter. Green ash grows somewhat more slowly, and cottonwood and willow more rapidly.

Tables VII, VIII, X, and XI show that a hundred 12-inch trees can easily grow on an acre, so that it is safe to assume that an acre of land will produce 20 cords of wood in thirty years. Leaving out of account the value of some of the trees for lumber, and assuming that all are sold at $2 per cord on the stump for firewood, the net return is $40. This is equivalent to 60 cents received yearly and placed at 5 per cent compound interest. As the annual return from

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FIG. 1.—THRIVING NATURAL GROWTH OF HACKBERRY, WHITE ELM, AND GREEN ASH, ALONG A CREEK IN NESS COUNTY, KANS.

FIG. 2.—A CLUMP OF BUR OAK WHICH HAS TAKEN POSSESSION OF A PRAIRIE WITHIN TWENTY-FIVE YEARS, BUFFALO COUNTY, KANS.

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pasturing this kind of land in western Kansas and Nebraska is usually not over 50 cents per acre, the tree crop actually yields 20 per cent more than the pasture.

The eagerness with which the natural forests were destroyed proves the value of timber to the people of this region. A second crop is sure to be worth no less.

TREE SPECIES FOUND IN WESTERN KANSAS AND NEBRASKA.

The great majority of the trees found within the regions covered by the present report entered it from the Missouri Valley region. This is true of all the trees of western Kansas, except the mesquite, wild china, and shittimwood, which reach up into the State from the south, and which, though interesting from a botanical standpoint, are not otherwise important. None of the Rocky Mountain species has succeeded in crossing the arid barrier interposed between them and western Kansas. The Arkansas River is the only highway of any consequence leading down from the mountains, and it has brought but a shrub or two.

Much of western Nebraska is really a foothill region, and in it eastern and western species mingle. The rock pine, western red cedar, Bebb willow, aspen, narrowleaf and lanceleaf cottonwoods, western birch, valley mahogany, western serviceberry, buffalo berry, and dwarf maple have, without doubt, come down from the Rocky Mountains.

Were it not for the first two of these mountain species, the pine and the cedar, the extreme western part of the State would contain little tree growth of any value.

The following pages contain a brief account of the trees found. The range given is in each case that within which they are definitely proven to occur. Later investigations may discover the same species in other localities, but it is believed that no species of any importance, from the forester's standpoint, has been omitted.

ROCK PINE.

The rock pine (*Pinus ponderosa scopulorum*), commonly called bull pine or yellow pine, is a variety of the western yellow pine of the Rocky Mountains, which it closely resembles. Smaller and hardier than the western yellow pine, however, and preferring lower situations, it is further distinguished from it by smaller cones, shorter needles, and the fact that the needles are often borne in bundles of two instead of three. It is most abundant in Cheyenne, Banner, Scotts Bluff, Sioux, Dawes, Sheridan, and Cherry counties, Nebr., and reaches its best development in Sioux and Dawes counties.

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The tree makes good coarse lumber, moderately durable posts, and good firewood. In many ways it is the most valuable tree of the region for general local uses.

RED CEDAR.

The red cedar (*Juniperus virginiana*) is the only native conifer of Kansas, and while widely distributed is seldom abundant. In Nebraska two species are recognized, *Juniperus virginiana*, of the eastern and central portions of the State, and *Juniperus scopulorum*, of the western part; but since the actual range of the two forms is undetermined and no distinction is made by the ordinary observer, the term red cedar is used for both in this report. The most obvious difference in the cedar of the two portions of the State is the extremely scrubby form often assumed by the native of the western part. The best of this was never fit for anything but posts and fuel, while from the trees farther east good telegraph poles were once produced. It is often found solitary on a bluff side, generally prefers the drier situations, and is quite indifferent to the kind of soil in which it makes its home. It grows slowly, but is wonderfully hardy.

The wood is valued chiefly for its great durability. Few woods of the United States last as long in contact with the ground, and consequently make such good posts and poles. Its value as lumber is not great.

BLACK WALNUT.

In Kansas the black walnut (*Juglans nigra*) is found in not more than one tier of counties west of the ninety-ninth meridian. It is abundant in various localities within its range and, though never attaining a large size, is a valuable tree. In Nebraska it is found only in Franklin County, on the Republican River, and in Cherry County, along the Niobrara. Its value is largely in its fruit, though the dark-colored heartwood is very durable and makes good posts, as well as good cabinet lumber. Rapidly grown trees have so much perishable sapwood that their lumber value is not great.

WILLOWS.

The black willow (*Salix nigra*) and the almondleaf willow (*Salix amygdaloides*) are the large tree willows of Kansas and Nebraska. They have been much confused and are quite variable, but the latter extends considerably farther west than the former; in fact, the only counties in Kansas where the black willow was definitely recognized in the course of these investigations were Barber and Comanche. The black willow is, perhaps, more widely distributed in Nebraska

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than in Kansas, but there, too, the predominating species is the almondleaf, which is common throughout the State. The black willow, when true to type, has much the narrower leaf, but the general appearance and habits of the two species are the same.

The Bebb willow (*Salix bebbiana*) comes into western Nebraska, and is most abundant in Sioux County. The largest trees attain a diameter of 8 inches and a height of more than 30 feet.

The sand-bar willow (*Salix fluviatilis*) is not usually considered a tree, though its manner of growth, and occasionally its size, entitle it to be classed as one. It is common along sandy streams, but is less plentiful or quite lacking on streams that have a heavy soil. The Platte and the Arkansas are particularly adapted to it. The value of the sand-bar willow lies in the fact that its wide-spreading roots, which send up a new shoot every few inches, make it the most effective agent in holding sand bars and preparing the way for more permanent species.

ASPEN.

Considerable aspen (*Populus tremuloides*) is found in a few Sioux County canyons. It is particularly abundant in Squaw Canyon, not far from the Wyoming line, where the larger trees attain a diameter of 8 inches and a height of 40 feet. The wood is valuable for fuel only.

HAIRY BALM OF GILEAD.

This tree (*Populus balsamifera candicans*), which Doctor Bessey describes in his report on the native trees and shrubs of Nebraska as "a tree with heart-shaped leaves, which are whitish underneath, found in Sioux County," is so much like the common cottonwood that it is not likely to be distinguished from it by the ordinary observer.

COTTONWOODS.

The common cottonwood (*Populus deltoides*) is the largest native tree of Kansas and Nebraska. It is the typical species of the Arkansas and the Platte, and is at home on every sandy stream (see Pl. IV). Trees of 5 feet or more in diameter are occasionally found, and those of 4 feet are not uncommon.

The lanceleaf cottonwood (*Populus acuminata*) and narrowleaf cottonwood (*Populus angustifolia*) have a wide distribution in western Nebraska. They are found in many canyons in Scotts Bluff and Sioux counties, growing in company with the common species, from which they differ only in the shape of the leaves. The narrowleaf cottonwood has a long, tapering, willowlike leaf, while that of the lanceleaf has a shape midway between it and the common one.

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Leaf forms of all three species are wonderfully variable in this region, and almost every gradation from the willowleaf to the deltoid can be found. The narrowleaf cottonwood is a rather small tree, but the lanceleaf is of the usual size. A tree of the latter species in Carter Canyon, in Scotts Bluff County, has a diameter of 4 feet and a height of 75 feet.

The wood is light and soft and perishable in the ground, but it furnishes, nevertheless, most of the common lumber of the region. In moist situations the tree grows so rapidly that no others can compete with it as a wood producer.

BIRCH.

The western birch (*Betula occidentalis*) is a small tree, resembling the cherry tree, which occasionally attains a diameter of 6 inches and a height of 30 feet. It is found in Sioux County, and is very abundant in several places in Scotts Bluff County. The wood is valuable for fuel, making a clear, hot fire.

The paper birch (*Betula papyrifera*) is reported by Doctor Bessey as occurring in Cherry County, on the north sides of high bluffs bordering the Niobrara River.

HORNBEAM.

The hornbeam, or ironwood (*Ostrya virginiana*), is reported to occur in Rock, Brown, Cherry, and Sioux counties, Nebr., but it is evidently quite rare, since it was not noted in observations extending from Valentine, in Cherry County, to the Wyoming line.

BUR OAK.

The range of the bur oak (*Quercus macrocarpa*) is much the same as that of the black walnut and the slippery elm, though it extends a little farther west than the former. The tree is very common east of the region here described, and is fairly abundant in Smith, Osborne, and Russell counties, Kans., and in Lincoln and Cherry counties, Nebr. It is quite plentiful within its range, attains a fair size, and in many places is spreading rapidly. (See Pl. VI.) The bur oak is hardy, and probably lives to a greater age than any other broadleaf tree mentioned in this report. The wood is very heavy, hard, strong, and tough, and is valuable for wagon and implement repairs. The heartwood is durable and makes good posts. As fuel it is better than any other wood of the region.

WHITE ELM.

The white elm (*Ulmus americana*) is one of the leading species in both States, but is lacking in southwestern Nebraska, and does not

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extend up the North Platte River farther than Lincoln County. It occurs along the Niobrara to the western part of Cherry County, and is common in Sioux and Dawes counties. It ordinarily makes a fine, shapely tree of good size (see Tables VII, VIII, IX, XI, and XII), and furnishes strong, tough wood, valuable for many local uses and for fuel.

SLIPPERY ELM.

The slippery elm (*Ulmus pubescens*) is a smaller tree than the white elm, has a more restricted range, and is ordinarily much less frequent, yet in Rawlins County, Kans., the slippery elm is much the more abundant of the two. The wood is less strong than that of white elm, but answers for many purposes and makes good fuel.

HACKBERRY.

The hackberry (*Celtis occidentalis*) is common in Kansas and Nebraska. Isolated clumps of it are even found in the sand hills, far from any other timber. Ordinarily it occupies a subordinate place in the forest, but it sometimes predominates (see frontispiece). The hackberry is a very hardy tree and can adapt itself to poor soils and dry situations. Under such conditions it grows slowly and is low and scrubby. In favorable localities it develops quite rapidly, and forms a shapely tree of moderate size. The wood is moderately strong and tough, and is used for the same purposes as elm.

RED MULBERRY.

The red mulberry (*Morus rubra*) is a rather small tree of moderate growth, occurring rarely in Smith, Osborne, and Russell counties, but quite abundantly in Barber and Comanche counties, Kans. The largest have a diameter breasthigh of nearly 18 inches. The wood is moderately strong, very durable, and makes good posts.

VALLEY MAHOGANY.

Though listed as a tree, this species (*Cercocarpus parvifolius*) is only shrublike in Nebraska. It is found on the bluffs in Cheyenne, Banner, and Scotts Bluff counties, but is of little importance.

WESTERN SERVICEBERRY.

The western serviceberry (*Amelanchier alnifolia*) is a rather small, bushy tree, found in Rock, Scotts Bluff, Banner, and Cheyenne counties, Nebr. It is very plentiful in some places and is valuable for its fruit.

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HAWS.

The haws are so variable that correct classification is difficult. They occur in a few localities in western Nebraska, but are small. The logspine haw (*Cratægus macracantha*) is found on Dead Horse Creek, in Dawes County; the scarlet haw (*Cratægus coccinea*) on the Dismal River, in Hooker County, while both species grow along the Middle Loup, in Thomas County, near Halsey. The scarlet haw is also reported from Brown and Cherry counties.

WILD PLUM.

The wild plum (*Prunus americana*) is a large bush, or small, thorny tree, common throughout Kansas and Nebraska. It usually grows in clumps in the bottoms of draws and canyons and along streams. The fruit is very variable in size, color, and quality, and is much sought for domestic use.

CHOKECHERRY.

The chokecherry (*Prunus virginiana*) is abundant in both States, and is much like the wild plum in its habits. The usual species in Kansas is undoubtedly *Prunus virginiana.* It has been asserted that in western Nebraska the western chokecherry (*Prunus demissa*) is the prevailing form; but if this be so, extended observation failed to establish the fact.

MESQUITE.

A few scattered specimens of this representative of the desert (*Prosopis juliflora*) are found in Barber and Comanche counties, Kans., where they undoubtedly reach the extreme northward extension of the species. The tree has a possible value in the warmer parts of this region, since it is known to have spread northward very rapidly through Oklahoma during the past twenty-five years.

COFFEETREE.

The coffeetree (*Gymnocladus dioicos*) is found occasionally in Kansas as far west as Comanche and Russell counties. At Wilmore, and on the Medicine River west of Medicine Lodge, it is abundant, and the reproduction in many places is excellent. The tree is near its western limit in the eastern part of the region here described, but, like so many others, may extend westward under favorable conditions. The wood is moderately strong and very durable and makes good posts.

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DWARF MAPLE.

The dwarf or mountain maple (*Acer glabrum*) is a small tree resembling the silver maple in appearance. It never reaches a diameter of more than a few inches and is often shrublike. Several clumps of it occur in Wright Canyon, southwest of Gering, Nebr. It is abundant in Sioux County, where it exhibits a tendency to come in on the bluffs after the pine is cut off.

BOXELDER.

The boxelder (*Acer negundo*) is common throughout Kansas and Nebraska. It occasionally predominates along the creeks, and in some places where the natural forest is extending it is the first tree to take possession of the ground. Reproduction often fails, however, because a very large percentage of the seed is sterile. The boxelder is generally a low, scrubby, short-lived tree, and suffers much from insects. The wood is weak, perishable, and of little worth. It is unfortunate that so many tree planters have been induced to set out this species. Almost any other is preferable.

WILD CHINA.

The wild china, or chinaberry (*Sapindus marginatus*), is a southern tree whose extreme northward extension, so far as noted, is in Russell County, Kans. It is particularly abundant in Hodgeman County, but in this region does not attain a large size. The wood is strong, tough, and, when large enough, is valuable for implements and repairs.

BASSWOOD.

According to Doctor Bessey, basswood (*Tilia americana*) extends westward to Brown and Rock counties in northern Nebraska. It is not found in western Kansas.

SHITTIMWOOD.

Shittimwood (*Bumelia lanuginosa*), a southern species, comes just across the Kansas line, being found occasionally in Barber County. Only small specimens are found there, but not far south, in Oklahoma, trees 18 inches in diameter are reported.

ASH.

The red ash (*Fraxinus pennsylvanica*) and green ash (*Fraxinus lanceolata*) resemble each other so closely in Kansas and Nebraska,

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and are so nearly alike in their qualities, that no distinction need be made between them. They are common throughout, and are probably the most abundant of all the broadleaf trees in the region. Though rather slow growers, the ashes are hardy, have a good form, and often reach a diameter of 2 feet.

The wood is tough and strong, but only moderately durable. It is valuable for tool handles and wagon work and makes good fuel. In some localities the trees are much injured by borers.

BUFFALO BERRY.

The buffalo berry (*Lepargyraea argentea*) is a small, thorny tree. It is a mountain species which has spread over nearly all of Nebraska, but is more plentiful in the western part of the State. It grows in clumps, like the wild plum, and attains a height of from 10 to 15 feet. The small, sour, currant-like red or yellow fruit is produced in great abundance and is much used for domestic purposes. The tree is very hardy, and is being propagated to some extent by nurserymen and horticulturists.

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